Translation

The following document is China's plan for applying high technology to the field of transportation. The plan sets qualitative goals for transport-related technological achievements for 2025, 2030, and 2035, and calls for the integration of technologies such as AI, blockchain, and cloud computing into China's traffic, transportation, freight, shipping, and logistics sectors.

Title
Outline of the Medium- to Long-Term Development Plan for Scientific and Technological Innovation in the Transportation Field (2021-2035)
交通领域科技创新中长期发展规划纲要（2021—2035年）

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Outline of the Medium- to Long-Term Development Plan for Scientific and Technological Innovation in the Transportation Field

(2021–2035)

Pursuant to the *Outline for Building China into a Transportation Powerhouse*[1] (《交通强国建设纲要》), and the *National Medium- to Long-Term Science and Technology Development Plan (2021-2035)* (《国家中长期科学和技术发展规划（2021—2035）》), this plan outline has been prepared in order to thoroughly implement the Party Central

[1] Translator's note: This translation renders the Chinese word 强国 qiángguó—which literally means "strong nation"—in English as "powerhouse," as in the phrase "transportation powerhouse" (交通强国). For a more thorough discussion in English of the Chinese word qiángguó, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/lexicon-wangluo-qiangguo/.

Committee's strategic deployments with regard to accelerating the construction of China into a science and technology (S&T) powerhouse and a transportation powerhouse, and coordinate promotion of S&T innovation-based transportation development."

I. Basis of Development

Since the 18th Party Congress [in 2012], the spirit of General Secretary Xi Jinping's series of important instructions on S&T innovation and transportation work has been thoroughly implemented in the transportation sector, and remarkable results have been achieved in the promotion of transportation S&T innovation. Our transportation infrastructure construction technology ranks among the world's best. A number of world-class projects, including the Hong Kong-Zhuhai-Macao Bridge and Beijing Daxing International Airport, have been completed and operated. Some types of transportation equipment are the best in the world, and deep-water high-precision gravel leveling barges, jumbo trailing suction hopper dredgers, and other major engineering equipment, as well as Fuxing China Standardized Electric Multiple Unit (EMU) trains, C919 large passenger aircraft, and other conveyance (载运) equipment represent our Made in China capabilities. New generation information technology (IT) is widely used in the field of transportation, the development of intelligent highways, intelligent shipping, intelligent high-speed rail, intelligent civil aviation, and intelligent warehousing and distribution has been rapid, and the level of transportation safety technical defense (技防) and emergency response capabilities have been significantly improved. Transportation S&T innovation capacity has been further strengthened, a number of key industry S&T innovation platforms have been identified in artificial intelligence (AI), biosafety, and other fields, and a number of national transportation science popularization bases (国家交通运输科普基地) have been built. The S&T talent cadre continues to grow, its structure and level are being optimized, and numbers of high-level S&T innovation leaders, innovation teams in key fields, and innovation talent training demonstration bases are emerging at an accelerating pace. Institutions and mechanisms for transportation S&T innovation continue to improve, mechanisms for "science-transportation synergy" (“科交协同”) cooperation and joint transportation technology innovation conferences, etc., have been established, and the environment for transforming S&T achievements into practical applications (科技成果转化) is being optimized. At the same time, there are still some shortcomings and weaknesses in transportation S&T innovation. Basic research and applied basic research are inadequate, the application of cutting-edge technological innovations is still a shortcoming, and in some areas reserves of key and core technology (关键核心技术) research are insufficient. The S&T innovation system still needs to be refined, the S&T innovation chain has yet to be optimized, high-level S&T innovation platforms and

high-level leading talents still need to be cultivated, and international S&T cooperation needs to be strengthened further.

II. Situation and Requirements

At present, the new round of S&T revolution and industrial transformation is evolving at an accelerating pace, the cross-fertilization of disciplines continues to develop, the interpenetration and integration of S&T and economic and social development are accelerating, and S&T innovation has become the main battlefield of international strategic games (战略博弈). Transportation is the pulse of the economy and the unifying bond of civilization, and has become a trailblazer of China's modernization. To accelerate the building of China into a transportation powerhouse, it is necessary to place S&T innovation in a more prominent core position, and strive to achieve high levels of S&T self-reliance (自立自强). Focusing on the world's cutting-edge S&T, we must: Accelerate the deep integration into transportation of cutting-edge technologies in fields such as AI, new materials, new energy, aerospace information, and marine and polar regions; accelerate the achievement of breakthroughs in core basic software, high-end control chips, engines, core components, and other key and core technologies; deepen the reform of transportation S&T innovation institutions and mechanisms; actively create an innovation environment that encourages innovation and tolerance of failure; and continue to enhance independent innovation (自主创新) capacity in transportation. Focusing on the main battlefield—namely the economy—and centered on supporting implementation of "Belt and Road Initiative"[2] construction, as well as Beijing-Tianjin-Hebei coordinated development, Yangtze River Economic Belt development, Guangdong-Hong Kong-Macao Greater Bay Area construction, Yangtze River Delta integrated development, Yellow River Basin ecological protection and high-quality development, and other strategic tasks, we must break through technical bottlenecks in the construction of major national strategic corridors, and improve the levels of intelligentization (智能化) and coordinated control in regional integrated transport networks, so as to construct and form an integrated transport system that is digitalized, networkized (网络化), intelligentized, and green. Focusing on major national requirements, and deeply implementing the innovation-driven development strategy, we must: Exploit the pulling effect of major application scenarios in transportation; promote the accelerated application of new generation information networks, intelligent green manufacturing, safe and efficient clean energy, efficient resource use, and ecological and environmental protection technologies; promote the engineering (工程化) and industrialization of S&T achievements; and support and lead the accelerated

[2] Translator's note: The "Belt and Road Initiative" (“一带一路”), abbreviated BRI, refers to the Silk Road Economic Belt (丝绸之路经济带) and the 21st Century Maritime Silk Road (21世纪海上丝绸之路).

building of China into a transportation powerhouse, thereby serving the building of an S&T powerhouse, a cyber powerhouse,[3] a Digital China, a peaceful and secure China (平安中国), a beautiful China, and other building efforts. Focusing on the people's lives and health, we must: Strengthen the research and development (R&D) of technology and equipment for water rescue and salvage, and handling of hazardous chemical transport emergencies; promote research on biosafety, medicine, health, and other technologies, and their application in transportation; improve the ability of transportation to maintain smooth traffic in response to major natural disasters, major safety incidents, major epidemic prevention and control, emergency relief, and other events; and improve the technology level of comprehensive transportation emergency assurance.

III. General Requirements

(i) Guiding ideology.

Take Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era as the guide, be firmly rooted in the new stage of development (新发展阶段), completely, accurately, and comprehensively implement the new concept of development (新发展理念), and serve the construction of the new pattern of development (新发展格局). Take the building of an S&T innovation system adapted to the needs of a transportation powerhouse as the main line, the R&D and application of S&T as the focus, the construction of S&T innovation capacity as the foundation, and the creation of an innovation-oriented policy system and institutional environment as the assurance, we shall comprehensively enhance the level of transportation S&T innovation development, so as to support the accelerated building of China into an S&T and transportation powerhouse.

(ii) Basic principles

Persist in goal-oriented leadership. With the benchmark being to complete construction of a world-leading transportation powerhouse that meets with the people's satisfaction and has strong assurance, we should: Build an S&T innovation system suited to the requirements of a transportation powerhouse; promote a shift in transportation development from being factor-of-production (要素)-driven to being innovation-driven; and support the creation of first-class facilities, first-class technology, first-class management, and first-class service.

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[3] Translator's note: Alternate English translations for the Chinese term wǎngluò qiángguó (网络强国)—here translated as "cyber powerhouse"—include "cyber superpower," "network powerhouse," "network superpower," and so on. For a more thorough discussion in English of the meaning of the term wǎngluò qiángguó, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/lexicon-wangluo-qiangguo/.

Persist in making breakthroughs in key areas. Starting from the urgent needs and long-term requirements for accelerating the building of China into a transportation powerhouse, we should: Strengthen the R&D and application of key general purpose technology, cutting-edge technology, modern engineering technology, and disruptive technology; and focus on making up the shortcomings in applied basic research, breaking through difficulties in key and core technology, and creating a good environment for S&T innovation.

Persist in collaborative integration. We should: Strengthen the collaborative advancement of S&T R&D, the conversion of achievements into practical applications, platform construction, talent training, and mechanism innovation; construct a government-industry-academia-research institute-user (政产学研用) collaborative innovation system; promote cross-sectoral, cross-departmental, and cross-regional integration of S&T innovation resources; strengthen the role of enterprises as the mainstay of innovation; and guide enterprises in increasing investment and enhancing their R&D capabilities.

Persist in independence (自主) and openness (开放). We should: Persist in S&T self-reliance, master key and core technologies, improve the innovation production chain, and enhance independent innovation capabilities. We must also strengthen international cooperation and exchanges, and actively use global S&T resources to promote the development of China's transportation S&T innovation.

(iii) Development goals

By 2025, basic and applied basic research will have been significantly strengthened, important breakthroughs will have been achieved in key and core technologies, integration of cutting-edge technologies into transportation will have been accelerated, the layout of S&T innovation platforms will have been perfected, the environment for developing talents will have been further optimized, mechanisms for converting S&T achievements into practical applications will be further smoothed, and the initial construction of an S&T innovation system adapted to the needs of accelerating the building of China into a transportation powerhouse will have been accomplished.

By 2030, important progress will have been made in basic and applied basic research, the level of independence (自主化) of key and core technology products will have increased significantly, cutting-edge technology and transportation will have been deeply integrated, transportation S&T innovation capabilities will have been significantly improved, and the transportation S&T innovation system will have been further improved.

By 2035, the overall level of transportation S&T innovation will have entered the world's front ranks, basic research and original innovation capabilities will have been comprehensively enhanced, key and core technologies will be independently controllable (自主可控), cutting-edge technologies and transportation will be comprehensively integrated, and an S&T innovation system that meets the needs of a transportation powerhouse will have been basically established.

IV. Main Tasks

(i) Raise the level of technology for high-quality infrastructure construction and maintenance.

Centered around raising the level of modernization in the construction, management, and maintenance of infrastructure, and focusing on making breakthroughs in basic theory, key general purpose technologies, and forward-looking technologies, we shall support the construction of a comprehensive three-dimensional (立体) transportation network that is safer, more durable, and more intelligent.

Study the theory and technology of comprehensive transportation. Study the theory of comprehensive transportation, and improve the theory of comprehensive transportation corridor planning and construction, integrated planning and construction of comprehensive transportation hubs, and the coordination and optimization of comprehensive transportation infrastructure project construction. Conduct research on the theory and technology of resilient transportation systems, master the basic theoretical methods of transportation infrastructure resilience assessment and risk prevention and control, and make breakthroughs in key technologies for the enhancement of transportation infrastructure resilience, coordinated operation and service of regional comprehensive transportation networks, and collaborative control of urban comprehensive transportation. Research and develop technologies and integrated operation service standards for the integrated planning and construction of trunk railways, intercity railways, urban (suburban) rail, and urban rail transit.

Make breakthroughs in national strategic corridor construction technology. Carry out research on technologies for major infrastructure construction such as river-crossing and sea-crossing tunnels, new land and sea tunnels in the western region, and canal connection projects; make breakthroughs in key technologies for long mountain-crossing tunnels, super-long-span bridges, submerged floating tunnels, high dam navigation locks, water conservation locks, high-speed (heavy-duty) railways, air (sea) systems, etc., and improve the technology levels in the reliability design and intelligent construction of transportation infrastructure under complex geological, hydrological, climatic, and other natural environmental conditions.

Carry out long-term performance observation research on transportation infrastructure. Build a scientific observation network for the long-term performance of transportation infrastructure, carry out observation and analysis of typical infrastructure operating conditions, study the underlying principles of the long-term performance evolution of structures and materials, and provide theoretical and data support for engineering structural safety assurance, design standard improvement, and science-based maintenance decision-making.

Strengthen research on intelligent maintenance technology for in-service infrastructure. Centered around in-service infrastructure performance improvement, make breakthroughs in whole-life-cycle intelligent monitoring of infrastructure health, accurate performance perception, autonomous early warning of risks, and other technologies; carry out R&D on technology and equipment for the intelligent detection, digital diagnosis, standardized assessment, and rapid disposal of infrastructure; develop an intelligent management and maintenance system for transportation infrastructure based on building information modeling (BIM) and the BeiDou [navigation satellite system]; and establish a basic information big data platform, so as to comprehensively promote preventive maintenance technology. Promote the R&D and application of intelligent rapid maintenance technology, research technical methods and standards systems for infrastructure structure reinforcement, durability improvement, post-disaster repair, etc. Promote blockchain technology-based whole-lifecycle quality control system and platform design for transportation infrastructure, and accelerate the construction of an integrated platform for major infrastructure safety and disaster risk control and emergency response measures.

(ii) Enhance the level of independence of key technologies for transportation equipment.

Centered around promoting the more intelligentized operation of China's transportation equipment, with cleaner power and lighter structures, as well as self-reliance in core basic components, we shall: Implement research to tackle key and core technologies for transportation, accelerate the R&D and upgrading of key special-use assurance equipment and new types of conveyance tools, and forge China's system of key and core technology and standards for transportation equipment.

Accelerate the upgrading of conveyance equipment technology. Strengthen research on the power transmission systems for automobiles, civil aircraft, ships, and other equipment, make breakthroughs in key technologies for high-efficiency, high-thrust, and high-power engines, research and develop core components such as high-power ship turbochargers and automotive chips, and promote the application of

certification, detection and monitoring, and operations and maintenance (O&M) technology for smart transportation equipment. Promote the research and development of new energy vehicles and intelligent connected vehicles (网联汽车), make breakthroughs in key technologies and equipment such as efficient and safe fully electric drives, fuel cells, overall vehicle design, and on-board intelligent sensing and control. Promote the independent design and construction of new energy and clean energy ships, smart ships, large and medium-sized cruise ships, polar navigation ships, etc., and the R&D of modern navigation equipment, and make breakthroughs in key technologies and equipment for shipboard intelligent perception and control. Promote the R&D of 400-km-per-hour high-speed wheel-rail (轮轨) passenger trains, achieve major breakthroughs with 30,000 ton-class heavy haul trains and 250-km-per-hour high-speed wheel-rail freight trains. Accelerate the R&D of large civil aircraft, heavy helicopters, intelligentized general aircraft, etc., and promote the improvement of a full spectrum of civil aircraft products. Promote the R&D of smart containers, smart recycling Euro containers (周转箱), rapid changeover and transfer equipment, and other new types of conveyance units.

Accelerate the R&D of key special-purpose assurance equipment. Strengthen the R&D of engineering equipment, carry out research on bridge and tunnel construction equipment, whole-span lifting and installation equipment, port machinery, etc., and make breakthroughs in technologies and equipment for ubiquitous sensing in intelligent site operating environments, autonomous operations and intelligent coordination, smart construction and industrialized production, etc. Strengthen the R&D of maintenance equipment, accelerate the R&D and application of intelligent engineering maintenance robots, and strengthen the R&D and application of self-propelled track maintenance equipment (自轮运转设备) for railway O&M, intelligentized equipment for the maintenance and repair of highway facilities without interrupting traffic, equipment for the intelligentized mapping and automated dredging of waterways, etc. Strengthen emergency rescue equipment R&D, develop traffic emergency handling equipment for natural disasters, major security incidents, and other emergencies, and research and develop large oil spill recovery vessels and key technical equipment, large deep-sea and far offshore multifunctional rescue vessels, key deep-water salvage equipment, smart underwater security equipment, applied deep saturation and diving technology and equipment, etc.

Make deployments for the R&D of new means of transport. Make deployments for the R&D of ultra-high-speed commercial aircraft, and make breakthroughs in aerodynamic layout shapes for wide ranges (宽域), aircraft-engine integration, comprehensive life support (生命保障) systems, and other design technologies. Actively explore the R&D of ultra-high-speed trains, and develop advanced rail

equipment based on new energy, material-structure integration (材料结构一体化), and cross-standards adaptation. Make deployments for the R&D of flying cars, and make breakthroughs in the integration of aircraft and cars, free switching between flight and ground travel, and other technologies.

(iii) Promote the intelligent and efficient development of transport services and organizations.

Centered around the construction of the Nationwide 1-2-3 Travel and Transportation Circle[4] and Global 1-2-3 Rapid Logistics Circle,[5] we shall raise the levels of convenient and smooth intermodal transportation of passengers and cost-effective multimodal transport of goods, accelerate the integration and innovative application of new generation IT in the field of comprehensive transport services, and improve the capacity and efficiency of comprehensive passenger and cargo transport services.

Promote technology upgrading for fast, convenient, and intelligentized travel. Tackle technologies such as those for the intelligent perception, monitoring, and analysis of travel behavior, the forecasting of road passenger traffic demand on holidays, the optimal layout and reconstruction of transport service facilities, the transparent and intelligent monitoring and early warning of the transport service process, and the monitoring, evaluation, and capacity regulation of traffic flows. Make breakthroughs in the design of intelligent, collaborative, and integrated rail transport service, new-type railway transport organization, and other technologies. Make breakthroughs in technologies such as autonomous aircraft airworthiness certification and wide-area cooperative sharing and safe and reliable services for air transport, establish an intelligent civil aviation information service technology system, and increase the achievement of domestic production of (国产化) key technology and equipment for the civil aviation system, so as to assure the all-weather, safe, and efficient operation of civil aviation. Improve the road passenger electronic ticket system and cross-transportation-network ticketing system, and build a full-chain, intelligentized, one-stop travel service system.

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[4] Translator's note: The "Nationwide 1-2-3 Travel and Transportation Circle" (全国123出行交通圈) is an abbreviation for China's goal to construct, by 2035, a nationwide ground and air transportation network that allows for one-hour commute times in metropolitan areas, two-hour journeys between urban agglomerations, and three-hour travel times between all of China's major cities (都市区1小时通勤、城市群2小时通达、全国主要城市3小时覆盖).

[5] Translator's note: The "Global 1-2-3 Rapid Logistics Circle" (全球123快货物流圈) is an abbreviation for China's goal to build, by 2035, a rapid shipping and logistics network able to ship goods to and from anywhere within China in one day, to ship to neighboring countries in two days, and to ship to any major city in the world in three days (快货国内1天送达、周边国家2天送达、全球主要城市3天送达).

Accelerate the research and application of intelligent logistics technology. Promote the development of multi-format and multi-habitat (多栖化) intelligent logistics; launch research on technologies such as smart coordination and integration of multimodal transport, smart perception and interconnection, smart monitoring, analysis, and evaluation, smart scheduling and integrated control of large logistics hubs, and logistics system emergency response and handling; research, develop, and apply technology and equipment for smart warehousing and fast loading and unloading, smart sorting and delivery, smart and rapid security inspection and voice processing, universal shipping codes, etc.; promote the R&D of monitoring and analysis technology for the road freight industry; and build a national multimodal transport public information platform to achieve the visualization, controllability, and traceability of the entire logistics process. Promote the development of urban underground intelligent logistics, and tackle technologies such as high-load lightweight vehicle design, low-cost tube rail (管轨) design, and intelligent O&M of logistics facilities and equipment. Grow new business formats (新业态) and new models such as supply chain services, cold chain express delivery, high-speed rail express, double-decker container transport, immediate direct delivery, and logistics delivery via unmanned aerial vehicles (UAVs) (or driverless cars).

Improve the level of technology for comprehensive management of urban traffic congestion. Promote the coordinated development of smart transportation and smart cities; make breakthroughs in technologies such as urban traffic demand forecasting and assessment simulation, traffic operation state perception, multi-agent (多智能体) simulation and decision-making for urban traffic, and data-driven traffic decongestion control and guidance technologies; promote the application of new generation IT in fields such as the coordinated development of transportation and cities, urban public transportation network layout optimization and precise vehicle scheduling, and dynamic operation monitoring; and raise the level of intelligentized urban traffic management with "holographic perception + collaborative linkage + dynamic optimization + precise control."

(iv) Vigorously promote construction of deeply integrated intelligent transportation.

Centered around the overall improvement of intelligent transportation development, we shall: Focus on tackling specialized software and special-purpose systems for transportation, accelerate the integration with transportation of innovative applications such as mobile internet, AI, blockchain, cloud computing, big data, and other new generation IT and aerospace IT; promote the innovative application of commercial passwords (商用密码) in the field of transportation; and accelerate the development of new infrastructure (新型基础设施) for transportation.

Strengthen the R&D of specialized software and special-purpose systems for transportation. Tackle bottlenecks in engineering design software, traffic simulation and testing software, and other specialized traffic software, and accelerate the achievement of domestic production of and application of BIM software. Accelerate the achievement of domestic production of, development of, and application of vessel traffic service (VTS) systems, ship automatic identification systems (AIS), convenient and inexpensive on-board communication systems, automated wharf operations systems, intelligentized port-vehicle collaboration systems, etc. Research and develop large-scale knowledge mapping and key AI algorithms to support intelligent transportation. Strengthen research on a complete package of big data center system technologies for comprehensive transportation systems.

Accelerate the integration of new generation IT and transportation. Accelerate the application of new generation IT in transportation public services, transportation monitoring and early warning, comprehensive emergency command and supervision, proactive response to transportation-related public opinion, driver training, and other fields. Promote the development and application of autonomous driving technology, make breakthroughs in integrated perception, vehicle-road information interaction, high-precision spatiotemporal services (时空服务), intelligent computing platforms, online evolution of perception, decision-making, and control functions, and other technologies, and promote the extension and application of autonomous driving and driver assistance in road freight, urban delivery, and urban public transport. Strengthen innovation in intelligent shipping technology, tackle the technology and standards of ship environment perception and intelligent navigation, ship-shore communication, testing and evaluation of smart shipping, and intelligent control, and promote the application of blockchain-based global shipping service networks. Research and develop smart railway technology, carry out research on new generation train control and railway-specific mobile communications technology, develop next generation train operation and control systems, and explore dispatching and command systems adapted to ultra-high-speed and multi-habitat-oriented transport systems. Develop intelligent civil aviation technology, make breakthroughs in the integrated operation of manned and unmanned aircraft, robust multi-element perception for civil aviation operation, broadband mobile communications, air-ground ubiquitous interconnection, intelligence integration (智能融合) applications, and other new generation intelligent civil aviation technology.

Accelerate the application of aerospace IT in the field of transportation. Make breakthroughs in high-precision, multi-source, and multi-dimensional data fusion technologies based on BeiDou precise perception, low earth orbit satellite constellation integrated communication, and satellite remote sensing; research and

develop smart terminals based on the new generation BeiDou system; and strengthen the application of BeiDou in dynamic monitoring, positioning, and navigation services for road transportation vehicles, ships, etc. Develop a full-time-domain, multi-dimensional, and high-quality comprehensive navigation assurance service system, and study the establishment of an electronic vector map space platform for multi-source data fusion and intelligent navigation. Make breakthroughs in aviation-satellite-earth integrated high-precision navigation, air-space-ground integrated enhanced airspace surveillance, and other key technologies.

(v) Promote integrated and collaborative safe transportation construction.

Centered around the new trends and requirements of transportation service safety and emergency response assurance for integrated three-dimensional traffic networks, we shall: Carry out R&D on technologies such as networked intelligent safety assurance for transportation, intelligent risk control, rapid emergency handling, etc., and improve transportation safety and emergency response capabilities.

Accelerate research on technology for the intelligent and collaborative control of road network risks. Research and develop technologies such as those for the monitoring, assessment, and diagnosis of the state of road traffic systems and transport processes, intelligent simulation of road network operations, and system resiliency optimization, and develop a geographic information system (GIS)-based road network security risk warning platform. Strengthen research on key technologies for road bridges, tunnels, and other key facilities, such as real-time dynamic monitoring of safety technology performance and early warning. Tackle technology for the intelligent monitoring and early warning of road traffic safety risks, and carry out research on road risk behavior correction and intelligent control technology. Research and develop safety and intelligent early warning, prevention, and control technologies for freight vehicle overloading and the transporting of dangerous goods. Promote research on safety and intelligent control technologies for mixed traffic systems of autonomous and driver-operated vehicles, and develop traffic safety facilities adapted to autonomous vehicles.

Build a ubiquitous and interconnected port and navigation safety and emergency assurance technology system. Strengthen the safety assurance of deep-sea and far offshore navigation; research and develop a deep-sea and far offshore three-dimensional supervision and emergency command system; develop high-precision deep-water surveying, intelligent navigational buoys, and other technology and equipment; strengthen the R&D of emergency handling technology for large marine oil spills, residual oil in sunken ships, hazardous chemical contamination, etc.; strengthen the R&D and application of search and rescue technology for persons

in distress; and build an integrated "land-sea-air-sky" water transportation safety assurance system. Improve inland waterway navigation safety assurance capabilities, tackle technologies such as three-dimensional sensing of navigation conditions for complex high-grade waterways and navigation structures, dynamic risk warning and control, and navigation safety emergency rescue, and make breakthroughs in key technologies for ship oil spill early warning, hazardous chemical transport safety emergency response, etc. Assure the safety of port operations, and study safety monitoring, early warning, and emergency handling technologies for loading, unloading, and storing dangerous cargo at ports; research and develop technology for the rapid detection and identification of people, vehicles, and goods at oil, gas, and chemical piers and tank areas; and develop equipment for the early warning and prevention of hazardous chemical leaks, explosions, etc.

Tackle proactive safety assurance technology for rail transit. Carry out R&D of key technologies for urban rail transit such as those for safety collaboration, networked organization of operations and emergency handling, equipment status monitoring and intelligent early warning, intelligent O&M, and intelligent control of protected areas. Make breakthroughs in technologies such as those for the monitoring, prevention, and control of railway operating environment risks based on air-sky-vehicle-ground information integration, all-round intelligent identification and early warning of high-speed railway perimeter intrusions, proactive safety assurance of high-speed train operation in complex and harsh operating environments, high-speed train system O&M assurance based on failure prediction and health management, safety monitoring and real-time tracking of dangerous goods throughout the rail transport process, and on-site monitoring and command and decision support for railway emergencies.

Strengthen the R&D of emergency assurance technology for comprehensive transportation. Enhance the capacity of comprehensive transportation emergency assurance under natural disasters and sudden major accidents; carry out research on technologies for the basic analysis of the laws of the causes and evolution of comprehensive transportation system loss of function and accidents, and for the accurate assessment of traffic delays; research and develop technologies for comprehensive transportation emergency control, emergency communications and service assurance, emergency command and decision-making, static and dynamic allocation of emergency resources, emergency evacuation, search and rescue, and handling; and tackle technologies for post-disaster transportation system function reconstruction and restoration. Improve transportation emergency response assurance capabilities for major epidemics, make breakthroughs in technologies and equipment for biological control and isolation in transport systems, and rapid allocation of rail transit mobile cabin hospitals (fangcang hospitals; 方舱医院), etc., and carry out

research on technologies and equipment such as those for the public health safety assurance on passenger ships (including cruise ships) and passenger terminals, and the design of safety systems for the prevention and control of pathogenic microorganisms. Enhance human safety emergency response capabilities, build a highly integrated human-computer feedback-based control system, and tackle key technologies for key job positions in transportation such as intelligent evaluation of fitness for duty, intelligent perception of on-duty status, and active intervention by human-computer interaction.

(vi) Build a whole-lifecycle green transportation technology system.

Centered around the requirements for implementing national deployments on carbon emission peak and carbon neutrality and the needs of green transportation development, we shall: Deepen the development and application of green technology for the whole lifecycle of transportation infrastructure, accelerate the application of new energy, clean energy, and new environmentally friendly materials in the field of transportation, and raise the overall sustainable development level of transportation.

Strengthen the research and application of green infrastructure construction and maintenance technology. Raise the level of green infrastructure construction and O&M technology, deepen the research and application of waste material recycling and reuse technology, research and develop new long-life, high-strength materials, biologically based and man-made alternative materials, environmentally friendly transportation paint, etc., and promote the extension and demonstration of technologies such as green roads, green ports, and green waterways. Raise the level of ecological protection and restoration technology, carry out research on technology for assessing the ecological and environmental impact and benefit enhancement of transportation corridors, and make breakthroughs in technologies for harmless crossing (无害化穿（跨）越), ecological management and restoration of all environmental elements, damaged ecosystem restoration, biocenosis structure reconstruction, etc.

Promote the research and application of green environmental protection technology for transportation services. Make breakthroughs in ecological carrying capacity-based transportation network optimization technology, carry out R&D of technology for the monitoring and assessment of transportation energy consumption and greenhouse gas and air pollutant emissions based on multiple data sources, promote the research and development of new technologies and equipment for the detection and traceability of pollutants from transportation vehicles, online monitoring and control of pollutants, prevention and control of noise pollution, etc., and promote the application of liquefied natural gas and other clean energy. Make breakthroughs in biodegradable packaging materials, intelligent packaging of mail and express mail,

cold chain delivery packaging, recycled and shared packaging, and other new materials and new technologies, so as to enhance the level of green development in the postal industry.

Accelerate the R&D and application of low-carbon transportation technology. Strengthen the research of carbon emission monitoring and accounting technologies and policies in transportation. Promote the integration of transportation and energy networks, carry out research on transportation-specific and non-carbon-based energy systems, distributed energy logical consistency (自洽), integrated construction, operations, and maintenance for transportation energy, source-grid-load-storage coordinated electrification of transportation, and other technologies, and study technologies and standards for the utilization of wind and solar energy within the scope of land used for transportation. Raise the level of low-carbon energy application technology, carry out R&D of technology for the application of electric energy, hydrogen energy, ammonia energy, solar energy, and other low-carbon energy in transportation vehicles, operational machinery, and other equipment.

(vii) Enhance S&T innovation capacity for transportation in the new era.

We shall: Deeply implement national S&T system reform and the requirements of relevant innovation system construction policies, focus on the basic establishment of an S&T innovation system adapted to the needs of a transportation powerhouse, and constantly increase transportation S&T innovation capacity.

Refine S&T innovation institutions and mechanisms. Improve the technology innovation mechanism that takes enterprises as the mainstay and features industry-academia-research institute-user integration. Establish and improve innovation-oriented business performance assessment and distribution mechanisms for state-owned enterprises, and increase the participation of enterprises in S&T innovation plans, programs, policies, and standards. Expand the scientific research-related autonomy of universities and research institutes, promote implementation of charter-based management (章程管理) in accordance with laws and regulations, allow qualified work units (单位) to appropriately increase the proportion of senior professional and technical positions in accordance with actual circumstances, and promote implementation of the contracting system[6] of transportation research

[6] Translator's note: In the context of Chinese government-funded S&T projects, the "contracting system" (“包干制”) refers to a system in which the funding agency gives the researchers who are contracted to carry out the project an overall budget and leaves it up to them how best to spend the funds. This differs from the typical process, in which the funding agency divides the overall budget into many different bins dedicated to specific stages and aspects of the project and insists that the researchers spend their funds according to this prearranged plan.

project funding and the "winner-takes-all open competition"[7] mechanism for tackling key and core technologies.

Refine the key S&T innovation platform system. Optimize the layout of key S&T innovation platforms in the field of transportation, strengthen the construction of national key laboratories, national technology innovation centers, engineering research centers, scientific observation and research field stations (野外科学观测研究站), scientific data centers, and other forms of cultivation, and optimize the adjustment of industry key laboratories (行业重点实验室), technology innovation centers, field scientific observation bases (野外科学观测基地), and other S&T innovation platforms, so as to create a key S&T innovation platform system characterized by complete coverage of fields, a rational structure, and a clear hierarchy. Implement enhancement plans for key S&T innovation platforms, promote the open sharing of scientific research facilities, instruments and equipment, and data with scientific research value, and improve the operational assurance, evaluation and assessment, and incentive mechanisms of key S&T innovation platforms.

Incubate a high-level S&T talent cadre. Innovate mechanisms for the cultivation, use, evaluation, and incentivizing of talents, deeply implement the transportation S&T innovation talent promotion plan, and cultivate a host of international-level strategic S&T talents, leading S&T talents, young S&T talents, and innovation teams. Optimize the layout of cutting-edge cross-cutting disciplines in universities, and promote the coordinated development of scientific research talents, high-end think-tank talents, and skilled talents. Promote implementation of the personnel staffing file system (人员编制备案制) in scientific research institutes and universities in accordance with regulations, and encourage the orderly and rational flow of S&T talents. For S&T talents, establish and improve a differentiated evaluation system, and diversified distribution mechanisms, oriented toward innovation ability, quality, and contribution, and thereby optimize the environment for talent development.

Strengthen international exchanges and cooperation in S&T innovation. Establish the Global Sustainable Transport Innovation and Knowledge Center. Strengthen joint R&D of advanced technologies with major innovation-oriented countries (创新型国家), expand the space for cooperation with developing countries on technologies in which China has an advantage (优势技术), programs, and standards, and strengthen cooperation with important international S&T organizations. Support enterprises and

[7] Translator's note: The idea behind "winner-takes-all open competition" (揭榜挂帅), in the context of PRC science and technology projects, is that the government openly lists the technological breakthrough(s) it desires. Any individual or group in society, not just a select few, are then eligible to win a cash award if they succeed in making the breakthrough. This concept is also known as the "bounty system" (悬赏制).

institutions in participating in or leading the revision of rules and standards within the framework of international organization affairs. Promote implementation of the transportation "Belt and Road Initiative" S&T innovation action plan. Study and promote the establishment of international S&T cooperation organizations in transportation, and support and encourage domestic transportation scientific research institutes and enterprises to establish overseas R&D centers in the field of transportation.

Strengthen the conversion of S&T achievements into practical applications. Improve policies for promoting the conversion of S&T achievements into practical applications, improve the property rights system for S&T achievements, and explore conferring ownership and long-term use rights for job-related S&T achievements on scientific researchers. Incubate professional technology transfer institutions and talents, construct pilot testing and industrialization vehicles for S&T achievements, and build a technical knowledge dissemination system based on professional qualifications. Promote the enjoyment, in accordance with regulations, of tax credits, accelerated depreciation of fixed assets, and other tax incentives for the purchase and use of first-ever products (or product lines) in the field of transportation. Support universities and research institutes in promoting the organic combination of achievement commercialization and entrepreneurship, and incubate entrepreneurial S&T-oriented enterprises. Improve feedback and evaluation mechanisms for the conversion of S&T achievements into practical applications, and build a performance evaluation system for the conversion of S&T achievements.

Build a high-quality system of technical standards and regulations. Promote the collaborative development of technology R&D and standards formulation and application, and promote the timely transformation of advanced and mature technologies into standards. Establish a standards coordination mechanism for emerging interdisciplinary fields, strengthen the layout of standards for forward-looking and strategic technologies, and accelerate the revision of standards for basic and key technologies. Promote the internationalization of standards in fields in which China has an advantage (优势领域). Centered around AI, autonomous driving, unmanned vehicles, and other cutting-edge fields, strengthen the relevant legislative research, and promote the acceleration of the legislative process.

Improve the ability to popularize S&T. Coordinate science popularization resources in the field of transportation, build high-standard national transportation science popularization bases, and increase the service ability of science popularization and education bases. Give full play to the role of scientists and engineers in the popularization of S&T, and promote the organic combination of technology R&D, achievement promotion, education and training, and S&T popularization propaganda.

Make full use of new generation IT to enhance service and dissemination capabilities for transportation science popularization.

V. Assurance Measures

(i) Strengthen organization and coordination.

We shall: Strengthen organizational leadership, establish and improve collaborative promotion mechanisms characterized by inter-ministerial collaboration, ministry-province linkage, and government-enterprise cooperation, deepen "science-transportation synergies," and improve the joint conference system (联席会议制度) for transportation technology innovation. Based on this planning outline, and taking into account their actual circumstances, the relevant departments and work units should strengthen their deployments and firmly grasp implementation.

(ii) Broaden funding channels.

Seek central government fiscal support for S&T R&D, promote the establishment of a National Joint Fund for Basic Research (国家基础研究联合基金) in the field of transportation, increase engineering construction project research and testing fees in support of S&T R&D and the promotion of achievements; actively seek fiscal support for transportation S&T work that is basic, long-term, or contributes to the public good; and encourage enterprises to establish stable growth mechanisms for S&T investment, strengthen S&T financial innovation, and improve diversified investment mechanisms.

(iii) Optimize the atmosphere for innovation.

We shall: Vigorously carry forward the spirit of scientists in the new era, and strive to create a good S&T innovation atmosphere featuring respect for knowledge, talent, and creativity, a focus on openness, and tolerance for failure. Protection of intellectual property rights will be strengthened, and the building of scientific research integrity will be accelerated, so as to create a clean and upright research environment. We will build a nationwide cloud platform for transportation news, propaganda, and information-sharing, strengthen the channeling of public opinion (舆论引导), publicize and report progress in and the effectiveness of S&T innovation, and fully mobilize the public's enthusiasm to widely participate in and support S&T innovation.